# VERSION 2

## DEFENSE THREAT REDUCTION AGENCY (DTRA)
## Small Business Innovation Research (SBIR) Program
### SBIR 21.2 Proposal Instructions


### 1. INTRODUCTION

The Defense Threat Reduction Agency (DTRA) mission is to enable the DoD, the U.S. Government, and International Partners to counter and deter Weapons of Mass Destruction (WMD – Chemical Biological, Radiological and Nuclear) and Improvised Threat Networks. The DTRA SBIR program is consistent with the purpose of the SBIR Program, i.e., to stimulate a partnership of ideas and technologies between innovative small business concerns and Research Institutions through Federal-funded research or research and development (R/R&D).

The approved FY21.2 list of topics solicited for in the Defense Threat Reduction Agency (DTRA) Small Business Innovation Research (SBIR) Program are included in these instructions followed by full topic descriptions. Offerors responding to this Broad Agency Announcement must follow all general instructions provided in the related Department of Defense Program BAA and submit proposals by the date and time listed in the DoD Program BAA. Specific DTRA requirements that add to or deviate from the DoD Program BAA instructions are provided below with references to the appropriate section of the DoD document.

The DTRA Small Business Innovation Research (SBIR) Program is implemented, administered, and managed by the DTRA Program Office. Specific questions pertaining to the administration of the DTRA SBIR Program and these proposal preparation instructions should be submitted to:

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| Mr. Mark Flohr | Defense Threat Reduction Agency |
| DTRA SBIR/STTR Program Manager | 8725 John J. Kingman Road |
| Mark.D.Flohr.civ@mail.mil | Stop 6201 |
| Tel: (571) 616-6066 | Ft. Belvoir, VA  22060-6201 |

For technical questions about specific topic requirements during the pre-release which begins April 21, 2021 through May 18, 2021 contact the DTRA Technical Point of Contact (TPOC) for that specific topic. To obtain answers to technical questions during the formal BAA open period, visit: https://www.dodsbirsttr.mil.

For questions regarding the DoD SBIR/STTR electronic submission system, contact the DoD SBIR/STTR Help Desk at dodsbirsupport@reisystems.com.

Proposals not conforming to the terms of this announcement will not be considered. DTRA reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality as determined by DTRA will be funded. DTRA reserves the right to withdraw from negotiations at any time prior to contract award. The Government may withdraw from negotiations at any time for any reason to include matters of national security (foreign persons, foreign influence or ownership, inability to clear the firm or personnel for security clearances, or other related issues).

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Please read the entire DoD announcement and DTRA instructions carefully prior to submitting your proposal as there have been significant updates to the requirements.

**The SBIR/STTR Policy Directive is available at:**
https://www.sbir.gov/sites/default/files/SBIRSTTR_Policy_Directive_2019.pdf.

## 2. SMALL BUSINESS ELIGIBILITY REQUIREMENTS

### 2.1 The Offeror

Each offeror must qualify as a small business at time of award per the Small Business Administration's (SBA) regulations at 13 CFR 121.701-121.705 and certify to this in the Cover Sheet section of the proposal. Those small businesses selected for award will also be required to submit a Funding Agreement Certification document prior to award.

### 2.2 SBA Company Registry

Per the 2019 SBIR-STTR Policy Directive, all SBIR applicants are required to register their firm at SBA's Company Registry prior to submitting a proposal. Upon registering, each firm will receive a unique control ID to be used for submissions at any of the eleven (11) participating agencies in the program. For more information, please visit the SBA's Firm Registration Page: https://www.sbir.gov/user/login/.

### 2.3 Use of Foreign Nationals, Green Card Holders and Dual Citizens

See the "Foreign Nationals" section of the DoD SBIR Broad Agency Announcement for the definition of a Foreign National (also known as Foreign Persons).

**ALL offerors proposing to use foreign nationals, green-card holders, or dual citizens, MUST disclose this information regardless of whether the topic is subject to export control restrictions. Offers must identify any foreign nationals or individuals holding dual citizenship expected to be involved on this project as a direct employee, subcontractor, or consultant.** For those individuals, please specify their country of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project. You may be asked to provide additional information during negotiations in order to verify the foreign citizen's eligibility to participate on a SBIR contract. Supplemental information provided in response to this paragraph will be protected in accordance with the Privacy Act (5 U.S.C. 552a), if applicable, and the Freedom of Information Act (5 U.S.C. 552(b)(6)).

Proposals submitted to export control-restricted topics and/or those with foreign nationals, dual citizens or green card holders listed will be subject to security review during the contract negotiation process (if selected for award). DTRA reserves the right to vet all uncleared individuals involved in the project, regardless of citizenship, who will have access to Controlled Unclassified Information (CUI) such as export-controlled information. If the security review disqualifies a person from participating in the proposed work, the contractor may propose a

suitable replacement. In the event a proposed person is found ineligible by the government to perform proposed work, the contracting officer will advise the offeror of any disqualifications but may not disclose the underlying rationale. In the event a firm is found ineligible to perform proposed work, the contracting officer will advise the offeror of any disqualifications but may not disclose the underlying rationale.

## 3. EXPORT CONTROL RESTRICTIONS

The International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, will apply to all projects with military or dual-use applications that develop beyond fundamental research, which is basic and applied research ordinarily published and shared broadly within the scientific community. More information is available at https://www.pmddtc.state.gov/ddtc_public.

The technology within some DTRA topics is restricted under export control regulations including the International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations (EAR). ITAR controls the export and import of listed defense-related material, technical data and services that provide the United States with a critical military advantage. EAR controls military, dual-use and commercial items not listed on the United States Munitions List or any other export control lists. EAR regulates export-controlled items based on user, country, and purpose. The offeror must ensure that their firm complies with all applicable export control regulations.

NOTE: Export control compliance statements found in these proposal instructions are not meant to be all inclusive. They do not remove any liability from the submitter to comply with applicable ITAR or EAR export control restrictions or from informing the Government of any potential export restriction as fundamental research and development efforts proceed.

## 4. CYBER SECURITY

Any Small Business Concern receiving a SBIR award is required to provide adequate security on all covered contractor information systems. Specific security requirements are listed in DFARS 252.204.7012, and compliance is mandatory.

## 5. PHASE I PROPOSAL GENERAL INFORMATION

### 5.1 Proposal Evaluation

DTRA will evaluate Phase I proposals using the criteria specified in Section 6.0 of the DoD SBIR Program BAA during the review and evaluation process. The criteria will be in descending order of importance with technical merit, soundness, and innovation of the proposed approach being the most important, followed by qualifications, and followed by the commercialization potential. With other factors being equal, cost of the proposal may be included in the evaluation. DTRA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded. The Government may withdraw

from negotiations at any time for any reason to include matters of national security (foreign persons, foreign influence or ownership, inability to clear the firm or personnel for security clearances, or other related issues). Phase I contracts are limited to a maximum of $167,500 over a period not to exceed seven months. For clarity, the stated maximum dollar amount is exclusive of the Discretionary Technical and Business Assistance (TABA) that firms may request.

DTRA participates in one DoD SBIR BAA each year and anticipates funding two Phase I contracts to small business concerns for each topic.

## 5.2   DTRA Support Contractors

Select DTRA-employed support contractors may have access to contractor information, technical data or computer software that may be marked as proprietary or otherwise marked with restrictive legends. Each DTRA support contractor performs under a contract that contains organizational conflict of interest provisions and/or includes contractual requirements for nondisclosure of proprietary contractor information or data/software marked with restrictive legends. These contractors require access while providing DTRA such support as advisory and assistance services, contract specialist support, and support of the Defense Threat Reduction Information Analysis Center (DTRIAC). The contractor, by submitting a proposal or entering into this contract, is deemed to have consented to the disclosure of its information to DTRA's support contractors.

The following are, at present, the prime contractors anticipated to access such documentation: Cherokee Nation Strategic Programs, LLC (contract specialist support), Kent, Campa, and Kate, Inc. (contract closeout support), Engility Corporation (a company under SAIC, Inc), (advisory and assistance services), Quanterion Solutions, Inc. (DTRIAC), Kforce Government Solutions, Inc. (financial/accounting support), and CACI (contract writing system administration). This list is not all-inclusive (e.g., subcontractors) and is subject to change.

## 6.  PHASE I PROPOSAL SUBMITTAL

Detailed guidance on registering in DSIP and using DSIP to submit a proposal can be found at https://www.dodsbirsttr.mil/submissions/learning-support/training-materials. If the proposal status is "In Progress" or "Ready to Certify" it will NOT be considered submitted, even if all volumes are added prior to the BAA close date. The proposer may modify all proposal volumes prior to the BAA close date.

Although signatures are not required on the electronic forms at the time of submission the proposal must be certified electronically by the corporate official for it to be considered submitted. If the proposal is selected for award, the DoD Component program will contact the proposer for signatures at the time of award.

Proposals addressing the topics will be accepted for consideration if received no later than the specified closing hour and date in the DoD Announcement . The Agency requires your entire proposal to be submitted electronically through the DoD Submission Web site

https://www.dodsbirsttr.mil/submissions/. A hardcopy is NOT required and will not be accepted. Hand or electronic signature on the proposal is also NOT required.

Proposals are required to be submitted in Portable Document Format (PDF), and it is the responsibility of submitters to ensure any PDF conversion is accurate and does not cause the Technical Volume portion of the proposal to exceed the 20-page limit. **Any pages submitted beyond the 20-page limit, will not be read or evaluated.** If you experience problems uploading a proposal, email DoD SBIR/STTR Help Desk at dodsbirsupport@reisystems.com

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MAXIMUM PHASE I PAGE LIMIT FOR DTRA IS 20 PAGES FOR

VOLUME 2, TECHNICAL VOLUME

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DTRA's objective for the Phase I effort is to determine the merit and technical feasibility of the concept. The contract period of performance for Phase I shall be seven (7) months (approx. 6 months technical work plus 1 month final report preparation) and the award shall not exceed $167,500. A list of topics currently eligible for proposal submission is included in these instructions, followed by full topic descriptions.

**Animal and Human Research**

Companies should plan carefully for research involving animal or human subjects, biological agents, etc. (see Sections 4.7 - 4.9 in the DoD Program Announcement). The few months available for a Phase I effort may preclude plans including these elements unless coordinated before a contract is awarded.

**Profit or Fee on Travel Costs**

Travel shall not be a profit or fee bearing cost element.

## 7. DECISION and NOTIFICATION

DTRA has a single Evaluation Authority (EA) for all proposals received under this solicitation. The EA either selects or rejects Phase I and Phase II proposals based upon the results of the review and evaluation process plus other considerations including limitation of funds, and investment balance across all the DTRA topics in the solicitation. To provide this balance, a lower rated proposal in one topic could be selected over a higher rated proposal in a different topic. DTRA reserves the right to select all, some, or none of the proposals in a particular topic.

Following the EA decision, the DTRA SBIR/STTR office will release notification e-mails for each accepted or rejected offer. E-mails will be sent to the addresses provided for the Principal Investigator and Corporate Official. Offerors may request a debriefing of the evaluation of their not selected proposal and should submit this request via email to: DTRA.belvoir.re.mbx.sbir@mail,mil and include "SBIR 21.2 / Topic XX Debriefing Request" in the subject line. Debriefings are provided to help improve the offeror's potential response to

future solicitations. Debriefings do not represent an opportunity to revise or rebut the EA decision.

For selected offers, DTRA will initiate contracting actions that if successfully completed will result in contract award. DTRA Phase I awards are issued as fixed-price purchase orders with a maximum period of performance of seven-months. DTRA may complete Phase I awards without additional negotiations by the contracting officer or without opportunity for revision for proposals that are reasonable and complete.

## 8. PHASE II PROPOSAL GUIDELINES

### 8.1 Phase II Proposal Introduction

Small business concerns awarded a Phase I contract are permitted to submit a Phase II proposal for evaluation and potential award selection. The Phase II proposals are best submitted no later than (NLT) 30 days AFTER the end of the 7 month Phase I period of performance.

All SBIR Phase II awards made on topics from solicitations prior to FY13 will be conducted in accordance with the procedures specified in those solicitations.

DTRA is not responsible for any money expended by the proposer prior to contract award.

DTRA has established a **40-page limitation** for the Technical Volume submitted in response to its topics. This does not include the Proposal Cover Sheets (pages 1 and 2, added electronically by the DoD submission site), or the Cost Volume, or the Company Commercialization Report. The Technical Volume includes, but is not limited to: table of contents, pages left blank, references and letters of support, appendices, key personnel biographical information, and all attachments.

Further details on the due date, content, and submission requirements of the Phase II proposal will be provided either in the Phase I award or by subsequent notification.

### 8.2 Phase II Proposal Instructions

Each Phase II proposal must be submitted through the DoD STTRSBIR Submission Web site by the deadline as specified in the Phase II Proposal Guidelines, or in the Phase I award or subsequent notification. Each proposal submission must contain a Proposal Cover Sheet, Technical Volume, Cost Volume, a Company Commercialization Report (see Sections 5.4.c.and 5.5 of the BAA Announcement), Volume 5, and Volume 6. The format should be similar to Phase I proposal except the Phase II Technical Proposal is limited to 40 pages. The Commercialization Strategy Volume should more specific than was required for Phase I.

As instructed in Section 5.4.e of the DoD SBIR Program BAA, the CCR is generated by the **submission website based on information provided by you through the "Company** Commercialization Report" tool.

**8.3    Commercialization Strategy**

See Section 7.3 of the DoD SBIR 21.2 BAA.

**8.4    Phase II Evaluation Criteria**

Phase II proposals will be reviewed for overall merit based upon the criteria in Section 7.0 of this Broad Agency Announcement and will be similar to the Phase I process.

**8.5  Profit or Fee on Travel Costs**

Travel shall not be a profit or fee bearing cost element.

## 9.  PUBLIC RELEASE OF AWARD INFORMATION

If your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released via the Internet. Therefore, do not include proprietary or classified information in these sections. For examples of past publicly released DoD SBIR/STTR Phase I and II awards, visit https://www.dodsbirsttr.mil.

## 10.  PROTESTS

Service of Protest (Sept 2006)

(a)  Protests, as defined in section 33.101 of the Federal Acquisition Regulation, that are filed directly with an agency, and copies of any protests that are filed with the Government Accountability Office (GAO), shall be served on the Contracting Officer (addressed to Mr. Herbert Thompson, Contracting Officer, as follows) by obtaining written and dated acknowledgement of receipt from (if mailed letter) Defense Threat Reduction Agency, ATTN: AL-AC (Mr. Herbert Thompson), 1680 Texas Street, SE, Kirtland AFB, NM 87117. If Federal Express is used for the transmittal, the appropriate address is: Defense Threat Reduction Agency, ATTN: AL-AC (Mr. Herbert Thompson), 8151 Griffin Avenue, SE, Building 20414, Kirtland AFB, NM  87117-5669.

(b)  The copy of any protest shall be received in the office designated above within one day of filing a protest with the GAO.

(End of provision)

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**DTRA 21.2 Phase I Topic Index**

DTRA212-001  Edge Computing for AI/ML based in forward deployed Cell Phones and associated equipment.

DTRA212-002  Distributed, Cooperative, Learning for Subterranean Robotic Autonomous Systems

DTRA212-003  Global Nano Aerial Terrestrial Sensing (GNATS)

DTRA212-004  Framework for Application Lifecycle Management and Continuous Integration for Pre-Exascale HPC Architectures

DTRA212-005  Advanced Optics Based Magnetic Field Diagnostic for NWE Testing

DTRA212-006  Algorithm that can locally link radiation detectors (of different resolutions) to enhance identification/ localization capability

DTRA212-007  Augmented Reality and Virtual Reality

DTRA212-008 Modernized Low Visibility RF Radio Capability

DTRA212-001 TITLE: Edge Computing for AI/ML based in forward deployed Cell Phones and associated equipment.

RT&L FOCUS AREA(S): Artificial Intelligence/ Machine Learning; Cybersecurity; Network Command, Control and Communications

TECHNOLOGY AREA(S): Battlespace; Electronics; Information Systems; Sensors

OBJECTIVE: Explore novel approaches to increase sense making for deployed forces using equipment they already carry and use. This will enable AI/ML Sense Making closer to the user with fewer delays, and reduced communications requirements, leading to a reduction of the human factors burden and physical burden by augmenting capabilities in their existing equipment.

DESCRIPTION: Develop, or demonstrate existing capabilities to create virtual processing networks using the increasing computational capabilities built in to commercially available cell phones. The ability to do secure processing close to the end user presents a rich resource for moving advanced and distributed processing AI/ML closer and closer to the end user. This will decrease the communications burden or bandwidth required while decreasing the time from potential detection to final action.

There is a movement to use inexpensive commercial equipment to enable operators in the field. The Android Tactical Assault Kit and it variants are now standard equipment for deploying forces. More specific to DTRA the Joint CTTSO DTRA Joint Operation Center/Tactical Assault Kit project provides sharing of imagery, planning tools, planning fragments, standard formatted request and report messages, language translation, and many additional operator developed capabilities. The old Galaxy S10 phones used with JOCTAK include dual CPU processors, 16 megapixel cameras, and at least 128 GB of ram1. The newer S21 version includes the faster dual processors, up to 512 GB of ram, a 40 MP Camera, dual encryption chips, and 5G capability2.

Each generation provides more capability without development cost to the end user.
The goal of this SBIR/SSTR topic is to explore harvesting and applying computational capabilities available in the current and next generation of cell phones used in DTRA Tactical Assault Kits, the Joint Operations Center Tactical Assault Kit (JOCTAK) and with the AI/ML capabilities under research in other parts of CX.

The emerging application and use of TAK/ATAK with the emergence of Civilian Tactical Assault Kit or the Team Awareness Kit is indicative of the commercial application of this research.

PHASE I: PHASE I: Shall execute an Analysis of Alternatives (AofA) and produce a Proof of Concept (PoC) implementation and architecture for creating secure virtual processing networks across commercially available cell phone used in the TAK/JOCTAK3 projects.

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PHASE II: Shall mature and fully integrate the architecture for the virtual network application with the continuous integration, continuous delivery (CICD) automated build process, located at the DI2E collaboration portal (www.di2e.net).

PHASE III DUAL USE APPLICATIONS:

All the deliverables of this topic shall be provided within the applicable laws and directions to include all allowed "government purpose rights", to the depository site.  Use and sale of the developed capabilities for commercial or State, Local, Territorial, and Tribal depend to the performer as prescribed by law.

REFERENCES:
1. https://www.samsung.com/global/galasxy-s10-/specs/;
2. https://www.samsung.com/global/galasxy-s21-ultra-5g/specs/;
3. https://www.civtak.org/tag/socom;

KEYWORDS: Edge Computing Android Tactical Assault Kit, Tactical Assault Kit Joint Operations Center Tactical Assault Kit Artificial Intelligence, Virtual Operating Systems Civ/TAK, TEam Awareness Kit

DTRA212-002 TITLE: Distributed, Cooperative, Learning for Subterranean Robotic Autonomous Systems

RT&L FOCUS AREA(S): Artificial Intelligence/ Machine Learning; Autonomy

TECHNOLOGY AREA(S): Electronics; Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: DTRA seeks the capability for its robotic systems, developed to explore and exploit, in GPS denied and communications limited environments, to learn from each other.

DESCRIPTION: Under the Modular Autonomous CWMD Systems (MACS) program, among others, DTRA is developing robotic and autonomous systems (RAS) to map, explore, and characterize subterranean facilities such as tunnels, caves, urban underground, and military purpose bunkers.  These facilities can be extensive and include multiple levels, elevation changes, obstacles, dim and variable lighting, and other challenging conditions. In addition, GPS is unavailable in such locations and communications between users and RAS, and amongst RAS platforms, is limited in bandwidth and range. The primary mission of these RAS is to explore, map, and catalog in these environments. However, autonomous resupply, payload delivery, network forming, and other mission scenarios should be considered. The environment and missions dictate that various types of robotic platforms are necessary and the communications challenge dictates that a high degree of autonomy is necessary on each platform with the associated sensors and data load. The communication challenge also limits the amount of data that may be passed from platform - to - platform and platform - to – user which makes application of a centralized learning concept less feasible. Distributed learning solutions, such as combinations of federated learning, transfer learning, and/or distributed multi-agent reinforcement learning are approaches that enable model training on a large amount of decentralized data. That is, they enable the model to be passed over the network rather than the data. This could be extremely beneficial to the underground exploration mission of DTRA if telemetry, health and status, map and environmental information (such as air flow, air quality, lighting, traction), as well as mission specific information such as the presence or concentration of certain chemicals or radiological information, could be encoded into a model that could be more easily distributed among platforms and users that have only intermittent connectivity. This could allow platforms to more quickly navigate in areas that have already been explored by other platforms and allow more effective decisioning by each platform individually.

PHASE I: Design and develop both the models and a learning architecture for robotic platforms exploring and cataloging a subterranean environment such as a tunnel or cave. In simulations of

subterranean areas with communication challenges, demonstrate the capability for multiple platforms to be controlled by humans and to learn from that control as to what are obstacles, what is of interest, what is not, etc. Locally train models on the data being collected and then update the models and for other platforms to receive and benefit from those updated models. Similarly, show platforms learning from each other by locally training models and then updating the shared model. A final demonstration should show at least more efficient path planning being developed by platforms that receive an updated model after a different platform has already explored an area.

PHASE II: Continue to develop the learning system and adapt it to the DTRA mission and DTRA platforms for incorporation into the group. Incorporate decisioning into the models that mitigates or adds information to the environmental conditions determined. Develop a tasking capability such that one platform may task other specialized platforms. Tasking may be dependent on specific object recognition or some other queue. Specializations may include carrying additional lighting, communications repeaters, CBRNE sensors, or other. Demonstrate the capability for the platforms to learn about the environment as well as the capabilities and limitations of the other systems in the group. A penultimate simulation demonstration should show autonomous tasking and path finding. For example, a UAV may be tasked to find the best route for a UGV to take given a particular set of obstacles and a system with specialized equipment will be called upon as required. Additionally, develop and simulate a small scale demonstration to be performed on actual hardware. Determine the hardware requirements and identify, develop, or otherwise procure it and perform a small scale demonstration in the same or similar environment that was included in the simulation.

PHASE III DUAL USE APPLICATIONS: Continue to develop and refine the Phase II product into a useful asset for DTRA. Adapt the product application for DTRA specific testing to include development or application of safety and security measures as required.

REFERENCES:
1.  Xiao, Y., Hoffman, J., Xia, T., and Amato, C. Learning Multi-Robot Decentralized Macro-Action-Based Policies via a Centralized Q-Net. https://arxiv.org/abs/1909.08776. 2020.;
2.  G. Sartoretti, W. Paivine, Y. Shi, Y. Wu and H. Choset, "Distributed Learning of Decentralized Control Policies for Articulated Mobile Robots," in IEEE Transactions on Robotics, vol. 35, no. 5, pp. 1109-1122, Oct. 2019, doi: 10.1109/TRO.2019.2922493.;
3.  Taylor, Adam & Dusparic, Ivana & Guériau, Maxime & Clarke, Siobhán. (2019). Parallel Transfer Learning in Multi-Agent Systems: What, when and how to transfer?. 10.1109/IJCNN.2019.8851784.;
4.  Rieke, Nicola. 2019. What is Federated Learning?https://blogs.nvidia.com/blog/2019/10/13/what-is-federated-learning/;
5.  Bhattacharya, Santanu. 2019. The New Dawn of AI: Federated Learning. https://towardsdatascience.com/the-new-dawn-of-ai-federated-learning-8ccd9ed7fc3a;

KEYWORDS: robotic and autonomous systems, GPS-denied, subterranean, artificial intelligence, communications, CBRNE sensors, repeaters, learning architecture, distributed learning, federated learning, transfer learning, distributed multi-agent reinforcement learning

DTRA212-003 TITLE: Global Nano Aerial Terrestrial Sensing (GNATS)

RT&L FOCUS AREA(S): Autonomy; Artificial Intelligence/ Machine Learning

TECHNOLOGY AREA(S): Air Platform; Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: To develop and demonstrate an innovative robotic system showcasing a nano aerial vehicle (NAV) marsupial concept with a GPS-denied guidance capability to advance the state of Counter Weapons of Mass Destruction (C-WMD) missions.

DESCRIPTION: Long-range delivery of sensors and strategic capabilities to support C-WMD activities are required by DTRA and supported DOD components. Currently, small UASs are restricted by their size and power which limits their ability to both travel over long distances and perform C-WMD missions of sufficient duration at a site once they arrive. This SBIR seeks research on a multi-layered/multi-platform (marsupial) system utilizing existing commercial/government off-the-shelf (COTS/GOTS) small Unmanned Aerial System (sUAS) vehicle capable of coordinated, GPS-denied, marsupial deployment and recovery to meet specific C-WMD missions in the objective area.

The overall intent is to develop or identify a NAV that can be carried in multiples, deployed to carry out a specific mission, and recovered by a larger robotic platform such as a sUAS (referred as a mothership). The coordination between the mothership and the NAV's is of critical importance to be investigated and defined early as the NAV's may be limited in their onboard computing and sensing capability due to SWAP requirements. As such, solutions that centralize the guidance and coordination on the mothership, leveraging the more extensive sensing and compute capabilities available to the larger platform along with some type of remote path planning and guidance of the NAV's, will be considered along with solutions that feature more autonomous NAV's. An architecture that allows flexibility in this mothership-NAV relationship as to where the NAV guidance autonomy and sensing resides is desired so as to enable different NAV variants to eventually be developed and employed. The system architecture, both physical and algorithmic, shall be open to encourage future development. Possible remote guidance concepts include laser guided NAV's with mothership instructions or autonomous remote control with the mothership relying on its own sensors to guide the NAV's. (new paragraph) While the desire is for an adaptable system, the specific problem to be designed to is a chemical sampling mission. In a GPS denied area, the system is to deploy NAV's that carry a material sampling detector (equal to or less than one ounce) to discover a chemical agent. A number (desired threshold of 5) of NAVs will be deployed to different locations, sample an area, and be recovered by the mothership in order to demonstrate this concept. The focus is on the ability of

the NAVs to navigate to target areas, recover a chemical sample, and return to the mothership after mission completion. The mothership may move to new areas after recovery of the initially deployed NAVs in order to deploy the other NAVs in separate areas. The command and control and mission planning of this system shall be made as intuitive as possible.

PHASE I: The focus of Phase I is to identify and mitigate the highest risks areas. Specific attention should be placed on identifying the overall system architecture to include command and control concepts and determining how to leverage advances in technology for the best balance of autonomy and sensing between the mothership and NAVs. Platforms that may be utilized for both the mothership and NAVs for the chemical sampling mission shall be identified and an analysis of alternatives shall be performed that discusses the physical, sensing, and computational capabilities of the platforms and any integration or adaptation efforts required. It is highly recommended to use GOTS or Blue UASs as possible as a waiver process will be required for others. Design or identify and prototype and demonstrate the carry, deploy, and capture mechanisms and procedures. Identify the navigation and guidance methodology to be utilized and identify and mitigate the highest risks. Specifically identify the autonomy stack necessary for the mothership and the NAV to perform the chemical sampling mission and document the open architecture communications and interfaces necessary between the NAV and mothership.

PHASE II: Refine the system design to include mission planning and overall command and control capability. Build the system to include a desired threshold of 5 NAVs and one mothership.

Design and execute a technical demonstration that showcases the system with the mothership from a significant standoff that is well outside the NAVs range away from the initial target area. The NAV release point must be in range close enough to allow the NAVs enough time to conduct chemical sampling and return to the sUAS within their flight time constraints. There may be multiple sites for the mothership to carry the NAVs and there may be multiple chemical collection sites at each deployment location. The chemical sampling mission will consist of a non-toxic chemical collected by a standard method provided by the Government (M9 paper or other chemical sampling that can be carried by a NAV).

The sensing, computing, and autonomy balance demonstrating guidance and coordination between the mothership and NAVs is the major deliverable. For the demonstration to be successful, it must show the capability of the system to accurately position the NAVs to perform their mission, in three dimensions, in a GPS denied environment. GOTs platforms may be available and should be considered along with other options. The final report should include all considerations used to prove the concept and all technical challenges that the experimental team were not able to overcome. The final report will also include videos and a briefing of all demonstration outcomes.

PHASE III DUAL USE APPLICATIONS: Finalize and commercialize NAV marsupial system with mothership platform/SUAS for use by customers (e.g. DTRA, DoD agencies, Warfighter, industry). Although additional funding may become available from DoD sources, the awardee

should look to other public or private sector funding sources for assistance with transition and commercialization.

REFERENCES:
1. Banker, S. 'Laser Guided Vehicles Navigate with Precision'. https://www.forbes.com/sites/stevebanker/2018/08/29/laser-guided-vehicles-navigate-with-precision/?sh=74c116975091;
2. D. A. Davis., "Pegasus Multi-Domain Can Fly and Operate on the Ground", unmanned system, Autonomous Media. (August 20, 2019). ;
3. Dziubinski, M. 'Training a neural network for driving an autonomous RC car'. https://medium.com/asap-report/training-a-neural-network-for-driving-an-autonomous-rc-car-3906db91f3e;
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KEYWORDS: Microelectronics, small Unmanned Aerial Systems, autonomy, autonomous, semi-autonomous, nano micro-aerial vehicles or nano-MAVs, Vertical take-off and landing or VTOL

DTRA212-004 TITLE: FRAMEWORK FOR APPLICATION LIFECYCLE MANAGEMENT
AND CONTINUOUS INTEGRATION FOR PRE-EXASCALE HPC
ARCHITECTURES

RT&L FOCUS AREA(S): 5G, General Warfighting Requirements (GWR); Nuclear

TECHNOLOGY AREA(S): Information Systems; Materials; Weapons

OBJECTIVE: The objective of this project is to develop a secure Application Lifecycle
Management (ALM) and Continuous Integration / Continuous Delivery (CI/CD) framework for
legacy codes. Such a capability would integrate existing tools into a cohesive framework to
automate a series of steps such as test suites, ensuring code coverage of testing, version control
e.g. Git & GitLab, streamlining of build process and bookkeeping of these steps/tests/versions.
Once built and tested, deploy the application code using a Singularity software container on
multiple physical systems, and eventually in a "cloud".

DESCRIPTION: The Defense Threat Reduction Agency (DTRA) uses High-Fidelity computer
codes to investigate weapon effects phenomenology and techniques for countering WMD. The
High-Fidelity codes have in some cases evolved over many decades. This topic will begin to
bridge the gap from legacy practices to modern practices that combine security, software
development and information technology operations (SecDevOps) that test the security of the
software as part of a continuous integration/continuous delivery (CI/CD) pipeline.

The government-owned computational fluid dynamics code, Second-order Hydrodynamic
Automatic Mesh Refinement Code (SHAMRC), is heavily used by many of the DTRA
programmatic areas utilizing High-Fidelity computer codes. It is a particularly challenging
application for containerized deployment because a pre-processor reads user input and generates
unique source code for each problem. The code is then compiled prior to execution.
SHAMRC capabilities include non-responding and responding structures, interactive particles,
several atmosphere models, multi-materials, many high explosive detonation models, a K-
Epsilon turbulence model, a particle surface heating model, non-equilibrium radiation diffusion,
water vaporization, and dust non-equilibrium chemistry. SHAMRC is second-order accurate in
both space and time, is fully conservative of mass, momentum, and energy, and runs in parallel
using Message Passing Interface (MPI). Because SHAMRC is export-controlled software,
another large legacy FORTRAN High Fidelity code may be used as a SHAMRC proxy in Phase
I.

Typically, ALM tools might include capabilities related to Requirements, Software & Hardware
Development, Quality Assurance & Test Management, Release & SecDevOps. Because this
effort is targeted towards existing legacy High Fidelity application codes, the emphasis should be
on Quality Assurance & Test Management, Release & SecDevOps. Component integrations
should be modular so that one tool such as GitHub for example, could be replaced with use of
GitLab, to meet the needs of a different commercial customer in Phase III. The entire framework
must run in user space without root access, although it may utilize existing underlying tools that
are installed by the system administrators such as Git, GitLab and Singularity.

PHASE I: Develop an approach for design of a secure ALM, CI/CD framework. The Framework design should encompass innovative use of existing open-source tools, such as Git, GitLab and the Singularity container using the fake root capability, with targets of Red Hat Enterprise Linux and SUSE Linux Enterprise Server. At the end of Phase I the performer should have a completed architecture and an early prototype with limited capabilities as proof of concept to demonstrate feasibility of the technical approach. For each component of the framework that is not an encapsulation of an existing tool, a stub may be used as a placeholder for capabilities to be added in Phase II.

PHASE II: Develop a production ready framework based on the Phase I approach and integrate with selected existing tools. Implement additional capabilities not available in existing tools to address other proposed features. Demonstrate the use of the framework on Department of Defense (DoD) High Performance Computing Program (HPCMP) systems on several High-Fidelity application codes, to include the SHAMRC code. The ability to migrate the ALM workflow and application code in a Singularity container from a DoD HPCMP physical system to a Cloud Service Provider is desirable. Cloud migration is subject to availability of cloud resources at Impact Level 5. An open research proxy may be used for development on Impact Level 2 resources.

PHASE III DUAL USE APPLICATIONS: The secure ALM, CI/CD framework and associated workflows developed for use on very demanding application codes will be well suited, once refined, for use on more general HPC workloads on pre-Exascale architectures. Improvements in this phase are expected to involve ease of use enhancements and hardening of the framework for use on a wide range of application software used in Government research and industry.

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KEYWORDS: High Performance Computing; HPC; HPCMP; SHAMRC; Singularity; Container; FORTRAN; SecDevOps; High Fidelity;

DTRA212-005 TITLE: Advanced Optics Based Magnetic Field Diagnostic for NWE Testing

RT&L FOCUS AREA(S): 5G, General Warfighting Requirements (GWR); Nuclear

TECHNOLOGY AREA(S): Nuclear; Sensors; Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: The objective of this effort is to develop an advanced optics based magnetic field sensor for Nuclear Weapon Effects (NWE) testing. The sensor should be low-cost and able to operate with high accuracy in a wide range of X-ray and gamma environments.

DESCRIPTION: Military system components are tested in X-ray and gamma radiation simulators, for time-varying Nuclear Weapon Effects (NWE), such as System Generated Electromagnetic Pulse (SGEMP), Internal EMP (IEMP), and Open Cavity SGEMP. These effects are caused by electrons emission from conducting surfaces which generate surface currents (with associated electric and magnetic fields). These magnetic fields can have strengths of order 1 to 1000 Amps/meter with rise times of order of nanoseconds (ns). It is important to measure the magnetic fields produced by pulsed X-ray exposures to validate models of a system's response. Traditionally, the magnetic fields of these NWE effects are measured with small B-Dot probes (simple induction coils), placed close to the external or internal surfaces of the test object. These sensors face challenges related to their miniaturization, Electromagnetic Interference (EMI) susceptibility and fielding considerations within a test object [1, 2]. Optical fiber based magnetic field sensors, offer several advantages which includes having a smaller size, reduced susceptibility to EMI noise and increased dynamic range [1]. These sensors are seldom fielded for NWE testing due to the requirement to be high speed, minimally intrusive and able to operate in a harsh environment [3]. The objective of this effort is to develop an advanced optics based magnetic field sensor appropriate for NWE testing.

DTRA seeks innovative ideas for the development of an advanced optics based magnetic field sensor suitable for NWE testing. The proposed magnetic field sensor should include the sensor probe as well as the measurement and recording instrumentation capable of nanosecond time resolution. The system must maintain the integrity of the magnetic field information sensed at the probe and transmitted to the recording instrumentation. The sensor probe should be low-cost, easily replaceable, small and able to operate with high accuracy in a wide range of X-ray and gamma environments. Phase 1 development should result in a conceptual design of the proposed sensor and demonstrates its feasibility for NWE related testing. Phase II development will further

optimize the design of the sensor, fabricate and demonstrate that the design meets or exceeds the following threshold {objectives}:

1.  B-Field Measurement Range: 0.01 to >1000 A/m
2.  Accuracy: better than 5%
3.  Bandwidth: >100 MHz
4.  Rise Time: <3.5 ns
5.  Be low cost and have a replaceable sensing element.
6.  Be compact: the sensing element to be no larger than 1cm3.

PHASE I: Investigation will develop a conceptual design of the optics based magnetic field sensor that, at a minimum, addresses the stated objectives presented in the Description. Demonstrate the feasibility of the sensor design with performance predictions based on peer-reviewed literature, physics-based modeling and simulation, and/or data obtained from laboratory testing of sensor components. Develop a Phase development II plan.

PHASE II: Based on the results of Phase I, develop and deliver a prototype that demonstrates the performance of the chosen technology for this application and meets all stated minimum requirements stated in the Phase II development plan and objectives stated in the Description. Collaborate with Government personnel to test the prototype over its full dynamic range to ensure the capability meets the performance goals.

PHASE III DUAL USE APPLICATIONS: Optimize sensor design and demonstrate performance in an operational environment. Develop manufacturing and commercialization plans for implementing the research in production and dissemination of the sensors, respectively. This technology would benefit any organization seeking a low cost, small, robust magnetic field sensor.

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KEYWORDS: Electromagnetic Sensor, Magnetic Sensor, Optical Fiber Magnetic Field Sensor, NWE, NWE Testing, SGEMP, IEMP

# VERSION 2

TRA212-006 TITLE: Algorithm that can locally link radiation detectors (of different resolutions) to enhance identification/ localization capability

RT&L FOCUS AREA(S): Nuclear; Artificial Intelligence/ Machine Learning

TECHNOLOGY AREA(S): Nuclear; Sensors

OBJECTIVE: Development of network hosted algorithms to link multiple and varied battlefield RN detectors to enable the fusing and processing of raw detector outputs into usable information.

DESCRIPTION: This topic seeks to develop radiation detection algorithms that would reside within a network and support the fusion of multiple and varied raw detector outputs and the processing of this data into useable information. Often, multiple detectors, and multiple detector variants are deployed to characterize a complex scene (i.e. stationary detectors, handheld radioisotope devices, vehicle-mounted detectors, and backpack detectors) within 1 square km. Currently, algorithms for identification and characterization reside on each individual detector and each detector provides its unique result. This topic aims to better utilize those data from multiple detector types and analyze data in a way as to enhance the overall mission's ability to identify and localize a radiation source in a complex scene. The intent is to change the level of analysis and potentially fuse data (gross gamma/neutron counts, gamma spectral data, and/or GPS data) to identify and characterize anomalies in radiological signatures quicker than current local algorithms on singular devices.

PHASE I: Identification of multi-radiation detector algorithms and demonstrate their potential to improve the identification, characterization, and/or localization of a radioactive source in a complex scene as compared to the singular detector algorithm. Multiple candidate algorithms shall be down selected for further development in Phase II. Demonstrate pathways for meeting the Phase II performance goals through feasibility studies at the end of Phase I.

PHASE II: Demonstrate enhanced identification, characterization and/or localization of radioactive sources with the multi-detector algorithm that fuses data (gamma and neutron radiation outputs, and GPS location/time) from disparate ground based and mobile detector types. Demonstrate improved performance of the multi-detector algorithm over single-system algorithms. The algorithm should support the integration of additional new detector types.

PHASE III DUAL USE APPLICATIONS: Field demonstration in radiation environment with users deploying multiple and varied radiation detectors linked via communications to a network node in which the algorithm receives detector outputs. The algorithm must conduct scene characterization in real-time as operators move through a complex environment with disparate detector modalities. The multi-system algorithm will be directly compared to legacy single-system algorithms to assess impact on mission. Develop commercialization and transition plan to DoD end users.

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DETECTION OF RADIATION SOURCES. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 784, 1 June 2015, Pages 326-331. Accessed from https://www.sciencedirect.com/science/article/abs/pii/S0168900215000686;

2. Joint Pub 3-11;

KEYWORDS: RN Detection, algorithm

# VERSION 2

DTRA212-007 TITLE: Augmented Reality and Virtual Reality

RT&L FOCUS AREA(S): Nuclear

TECHNOLOGY AREA(S): Human Systems; Information Systems; Nuclear; Sensors; Battlespace; Electronics

OBJECTIVE: AR/VR evaluation tool that allows operators to walk through challenging life scenariosnuclear response scenarios (includes anomalies like shadowing, spotlighting, and attenuation effects) with radiation detectors.

DESCRIPTION: Develop software to support testing and evaluation of radiation detectors and their use in challenging life-like nuclear response scenarios without the use of radiological sources. Solutions to the problem set will focus on ensuring the technologies can effectively mimic real-world anomalies such as spotlighting and attenuation effects. Possible solutions may inject data in into sensors directly. The intent is to customize commercially available augmented reality and virtual reality solutions and applythem to the recreation of complex nuclear response scenarios. The solution should be flexible and agile enough to be quickly applicable to multiple mission locations, source configurations, and radiation detection systems.

PHASE I: Working Prototype-Technology Readiness Level 4

PHASE II: Robust Prototype TRL 6

PHASE III DUAL USE APPLICATIONS:

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1. Mossel, A., Peer, A., Goellner, J., & Kaufmann, H. (2017). REQUIREMENTS ANALYSIS ON A VIRTUAL REALITY TRAINING SYSTEM FOR CBRN CRISIS PREPAREDNESS. Proceedings of the 59th Annual Meeting of the ISSS - 2015 Berlin, Germany, 1(1). Retrieved from https://journals.isss.org/index.php/proceedings59th/article/view/2486;
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KEYWORDS: Augmented and Virtual Reality

VERSION 2

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DTRA212-008 TITLE: Modernized Low Visibility RF Radio Capability

RT&L FOCUS AREA(S): Artificial Intelligence/ Machine Learning; 5G, General Warfighting Requirements (GWR); Cybersecurity; Network Command, Control and Communications

TECHNOLOGY AREA(S): Information Systems; Sensors; Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: To develop a low visibility, jamming resistant, RF radio that is compatible with NE-CO sensors and operates on the Tactical Assault Kit (TAK) ecosystem. It will facilitate low-visibility CBRN Search Operations by the Technical Support Groups.

DESCRIPTION: TSG's are tasked with providing the Geographic Combatant Commanders (GCC) with a tactical, low-visibility CBRN search capability. The TSG's currently use Slingshot RF radios, and GSM/cellular to provide commanders the ability to command and control teams during search operations.

Presently, the RF radios used by TSGs do not have the ability to pass spectral data and is limited to a 900MHz ISM band, which is restricted in certain COCOMs, thus limiting tactical commanders in their communication PACE plans. Large area CBRN search operations require the deployment of a multitude of sensors, both statically and dynamically, throughout the defined mission space. This requires the simultaneous transmission of dozens of data streams in environments that are RF congested. The utilization of novel AI/ML algorithms to optimize RF waveforms in real time will improve the TSG's ability to locate and detect material of concern during search operations. This novel approach to waveform generation will allow TSGs to operate in all publically available ISM bands at 1 watt power levels which require little or no spectrum coordination with the host country, minimize the RF footprint, and are resistant to detection and countermeasure by technologically advanced adversaries.

To solve this challenge, TSGs require a new RF radio system which is interoperable with current and future NE-CO sensors and CBRN TAK plugins, providing TSG's with a flexible communications pathway, capable of relaying 300 kbps or higher for spectral analysis. Additionally, the new RF radio option should have 3 ISM band options, use minimal power, maintain a similar size or smaller than the current RF radio systems, incorporate waveforms purpose built to avoid detection, and are resistant to jamming. This would allow TSG's to adjust

# VERSION 2

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their communications PACE plan with minimal effort or host nation clearances, while maintaining operational effectiveness in a low visibility environment.

If successful, this RF radio system would provide TSG's and their supported forces with greater communications interoperability, allowing for better C3, faster identification and spectral analysis, and better allocation of operational resources.

PHASE I: Identify possible RF radio solutions. Requirements will include biweekly project updates, a final technical report, and successful live CONOP demonstration to include TAK functionality, sensor integration, and communications capabilities. Should include user interface for TAK a radio and network configuration as well as ML/AI capabilities to prevent jamming.

PHASE II: After identifying possible solutions, developer will be required to continue biweekly project updates and compile a final technical report. Additionally, developer will provide 1 prototype low visibility system for internal testing and demonstration as well as a live CONOP demonstration. Developer will demonstrate inclusion of AI capabilities and bandwidth for spectral analysis, as well as for jamming resistance during preliminary testing.

PHASE III DUAL USE APPLICATIONS:

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KEYWORDS: Nuclear Search, AI/ML, Signal Processing, TAK, Communications, Bandwidth

# VERSION 2

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